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REPLY TO ATTN OF: GP

(NASA-Case-MFS-22145-1) SELF-ENERGIZED PLASMA COMPRESSOR Patent (NASA) 4 p CSCL 20I Avail: US Patent Office 00/75 N75-13625 Unclas 05528

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,854,097

Government or Corporate Employee : Nat'L Academy of Sciences WASH, DC

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : MFS-22,145-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES /X/ NO / /

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

Bonnie L. Woerner
Enclosure

MFS-22,145-1

United States Patent [19]

James C. Fletcher et al.

[11] **3,854,097**

[45] **Dec. 10, 1974**

[54] **SELF-ENERGIZED PLASMA COMPRESSOR**

[76] Inventors: **James C. Fletcher**, administrator of the National Aeronautics and Space Administration with respect to an invention of; **Edward L. Shriver**, 4505 Garth Rd., S.E., Huntsville, Ala. 35802; **Eduard B. Igenbergs**, Rauchstrasse 3, 8000 Munich 80, Germany

[22] Filed: **June 6, 1973**

[21] Appl. No.: **367,606**

[52] U.S. Cl. **328/233**, 176/3, 313/63, 315/111

[51] Int. Cl. **H01j 23/26**

[58] Field of Search 328/233–238, 328/239; 313/62, 63; 176/3; 315/111

[56] **References Cited**

UNITED STATES PATENTS

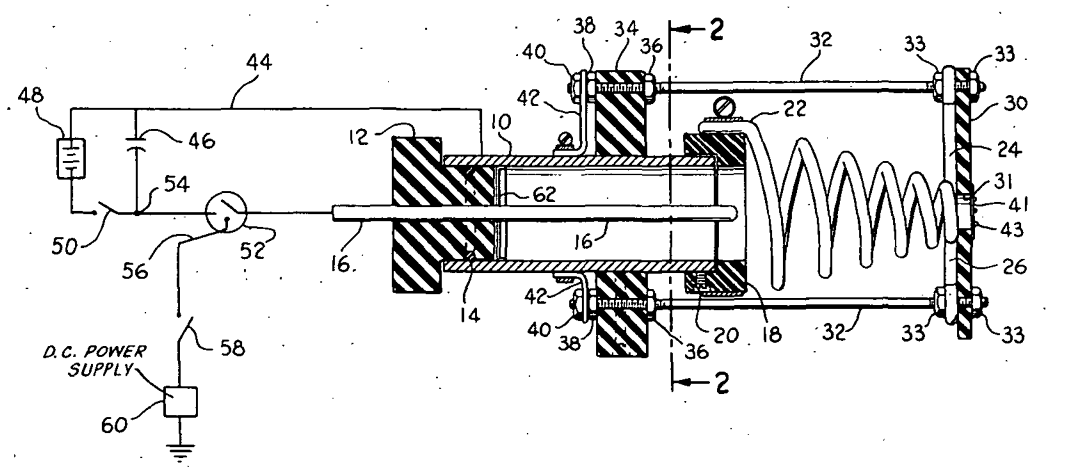
3,225,236	12/1965	Meyer	176/3 X
3,677,889	7/1972	Coensgen et al.	176/3
3,718,836	2/1973	Bain et al.	313/63 X
3,757,518	9/1973	Bahr	313/63 X

Primary Examiner—Alfred L. Brody
Attorney, Agent, or Firm—Wayland H. Riggins; L. D. Wofford, Jr.; John R. Manning

[57] **ABSTRACT**

A self-energized plasma compressor which compresses plasma discharged from a coaxial plasma generator. The device includes a helically shaped coil which is coaxially aligned with the center axis of the coaxial plasma generator. The plasma generator creates a current through the helical coil which, in turn, generates a time varying magnetic field that creates a force which acts radially upon the plasma. The coaxial plasma generator and helical coil move the plasma under high pressure and temperature to the narrow end of the coil. Positioned adjacent the narrow end of the coil are beads which are engaged by the plasma to be accelerated to hypervelocities for simulating meteoroids.

2 Claims, 2 Drawing Figures



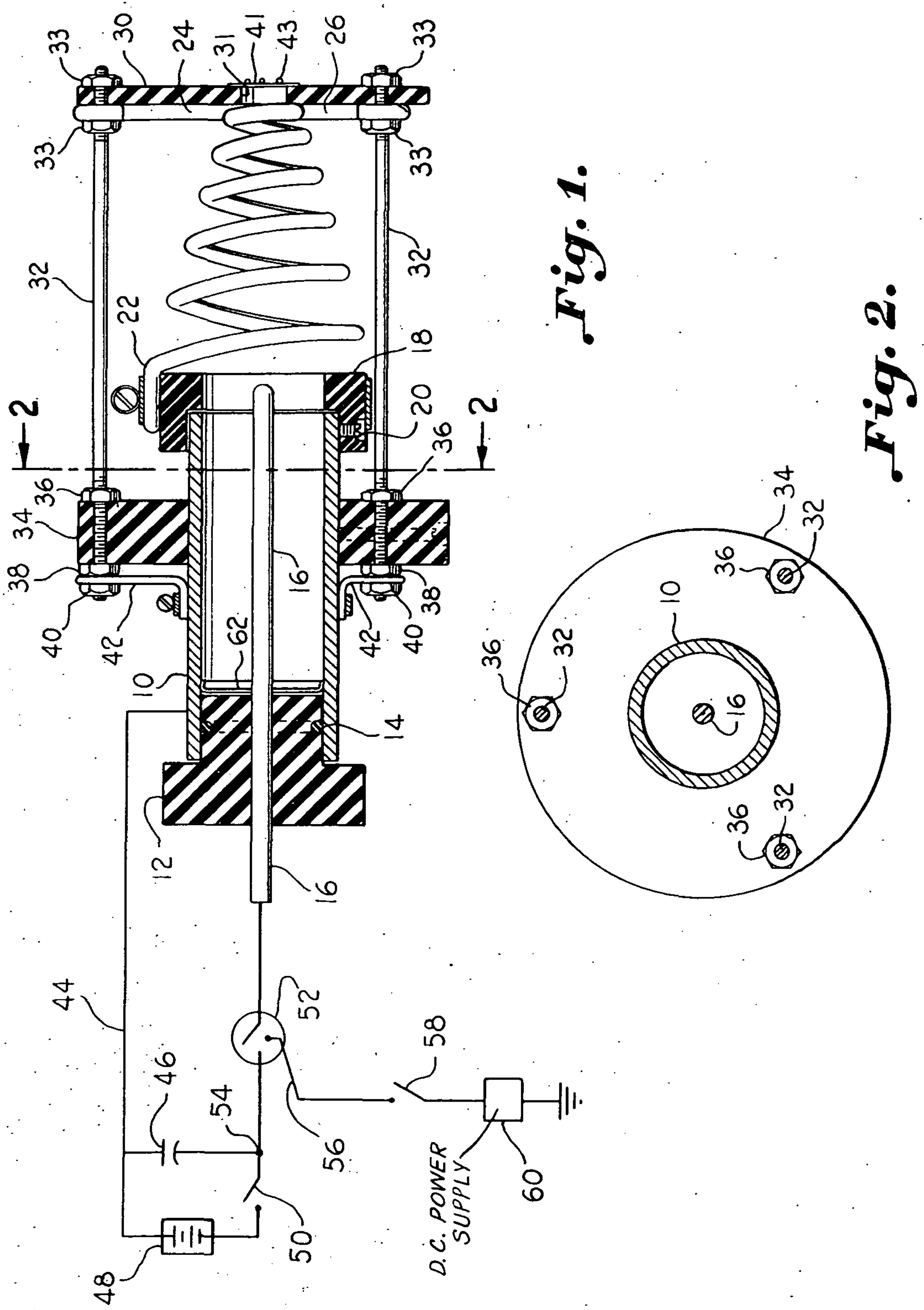


Fig. 1.

Fig. 2.

SELF-ENERGIZED PLASMA COMPRESSOR

ORIGIN OF THE INVENTION

The invention described herein was made in performance of work under a NASA Contract, and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435;42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

This invention relates generally to a plasma generator and more particularly to a plasma generator constructed to propel small projectiles to hypervelocities.

Heretofore, in order to propel small objects, such as beads, at hypervelocities for simulating meteoroids that may be encountered while travelling in outer space, it has been necessary to propel such from chemical explosions, from electrically exploded wires, or from electrostatic accelerators. While these apparatus may be able to propel very small particles at hypervelocities, they are not satisfactory for larger particles.

Devices have been developed, such as shown in U.S. Pat. No. 3,579,028 and U.S. Pat. No. 2,992,345, for focusing plasma in order to obtain very dense high-velocity plasma bursts. However, such devices do not include a self-energized helical coil which moves the plasma to a narrow end of the coil for engaging objects to propel them at hypervelocities.

SUMMARY OF THE INVENTION

The plasma generator constructed in accordance with the present invention is a self-energized plasma compressor which compresses the plasma discharge from a coaxial plasma generator. This system includes a helical coil which is situated coaxially with the center axis of a coaxial plasma generator. The large diameter end of the helical coil extends around the outer end of a cylindrical electrode forming a part of the coaxial plasma generator and extends outwardly therefrom. The outer small diameter end of the helical coil is connected to the cylindrical electrode of the coaxial generator. Thus, when the plasma generated within the coaxial generator begins to leave the cylindrical electrode it forms an electrical path from the end of the rod electrode to the helical coil. Current begins to flow through the helical coil producing a time varying magnetic field which, in turn, creates a circular current within the plasma inside the coil. The interaction of this current density with the time varying longitudinal magnetic field creates a force which acts radially upon the plasma so as to compress the plasma towards the axis of the helical coil. During this compression the plasma is heated to a high temperature. By positioning beads on a thin film member, such as mylar, the plasma penetrates the film to propel the beads at hypervelocities.

Accordingly, it is an important object of the present invention to provide a plasma generator which can propel objects such as glass beads, at hypervelocities.

Another important object of the present invention is to provide a self-energized plasma compressor, which is simple in construction and can be reused with a minor amount of servicing.

Still another important object of the present invention is to provide a self-energized plasma compressor which heats and densifies plasma so as to allow such to be expelled through a small opening to propel glass beads and the like at hypervelocities.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view, partially in schematic form, illustrating a self-energized plasma compressor constructed in accordance with the present invention, and

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring in more detail to the drawings, there is illustrated a plasma generator, which has a cylindrical elongated annular electrode **10** constructed of any suitable material, such as steel. An insulating plug **12** is carried on the inner end of the electrode **10** and has an O-ring **14** provided in an annular groove therein for producing a positive seal between the cylindrical electrode **10** and the plug **12.** An elongated rod electrode **16** extends through the plug **12** along the longitudinal axis of the cylindrical electrode **10.** The outer end of the rod electrode **16** extends slightly beyond the cylindrical electrode **10.**

An insulating ring **18** is carried on the outer end of the cylindrical electrode **10** and is secured thereto by a setscrew **20.** The opening in the insulating ring **18** is of the same diameter as the internal diameter of the cylindrical electrode **10.**

An electrically conductive helical compressor coil **22** has one end secured to the outer surface of the insulating ring **18** and extends outwardly in a helical spiral. The helical spiral has a large diameter adjacent the insulating ring **18** and such decreases towards the outer end. The outer end of the helical coil **22** is electrically connected to conductors **24** and **26** which extend radially outwardly from the longitudinal axis of the device. The conductors **24** and **26** have looped outer ends through which bolts **32** extend for securing such to a circular insulating spacer plate **30.** The ends of the bolts **32** have threads thereon, upon which nuts **33** are carried so that the looped end of the conductors **24** and **26,** as well as the spacer plate **30** can be sandwiched therebetween for securing such together. The elongated bolts **32** extend rearwardly through another nonconductive coil spacer plate **34** which is carried on the cylindrical electrode **10.** Nuts **36** and **38** are carried on opposite sides of the spacer plate **34** for securing the bolts thereto. The outer end of the bolt **32** has a nut carried thereon for securing one end of an electrical conductor **42** thereto. The other end of the electrical conductor is connected to the cylindrical electrode **10.**

The outer spacer plate **30** has a hole **31** centrally located therein, which is in alignment with the small diameter end of the helical coil **22.** Extending over the hole **31** is a thin mylar member **41** which has beads **43** positioned thereon. These beads **43** are the beads which are desired to be propelled at hypervelocities.

In order to energize the plasma generator an electrical conductor **44** is connected between the cylindrical electrode **10** and one side of a capacitor bank **46** shown schematically as a single capacitor. Also, connected to the same side of the capacitor bank **46** is the output of a D.C. power supply **48.** The other side of the D.C. power supply **48** is connected through a switch **50** to

one electrode of an ignitron switch **52**. Interposed between ignitron switch **52** and the switch **50** is a junction **54** to which the other side of the capacitor bank **46** is coupled. A control electrode **56** of the ignitron switch **52** is connected through a switching mechanism shown schematically at **58** to one side of a D.C. power supply **60**. The other side of the D.C. power supply **60** is grounded.

In operation, upon closing the switch **50** of the D.C. power supply **48** such causes the capacitor bank to charge to a predetermined level. When switch **58** is closed such, in turn causes the ignitron switch **52** to close. Upon closing of the ignitron switch **52** the capacitor bank **46** discharges through the central electrode **16**, a circular aluminum foil **62**, cylindrical electrode **10** back through lead **44** completing the circuit. As current flows through the aluminum foil **62** such causes the foil to be heated and ionized. When the foil **62** is ionized it forms a plasma which is accelerated out of the cylindrical electrode **10** by the magnetic field surrounding the elongated electrode **16**. As this plasma exits from the insulating ring **18** it forms an electrical path from the end of the elongated electrode **16** to the helical coil **22**. Current begins to flow through the helical coil **22** creating a longitudinal magnetic field within the coil **22** which varies in time with the potential applied to the electrodes **10** and **16** of the coaxial plasma generator.

This time varying magnetic field creates a circular current within the plasma inside the coil **22**. This circular current interacts with the axial magnetic field and creates a radial force by which the plasma is contained within the coil. Since the plasma leaves the cylindrical electrode **10** of the coaxial generator with a velocity component directed along the longitudinal axis, it is compressed into the narrow end of the compressor coil **22**.

When the potential applied to the rod electrode **16** and the cylindrical electrode **10** of the coaxial generator begins to decrease the magnetic field created by the helical coil **22** also begins to decrease, and the current induced in the plasma by the magnetic field changes direction. Since the magnetic field has not changed direction but the current in the plasma has, the force on the plasma tends to drive it away from the longitudinal axis and the plasma is forced out of the coil **22** in a direction perpendicular to the longitudinal axis of the coil.

During the compression the dense plasma in the narrow end of the coil **22** is under high pressure and temperature, and is thus available for use as a high pressure gas. This plasma ruptures the thin mylar foil **41** and strikes the beads causing the beads **43** to be propelled at a hypervelocity.

During the energization of the plasma compressor it is positioned within a vacuum chamber which surrounds the entire apparatus. In one particular test the beads which are expelled when the mylar member **41** is ruptured by the plasma are propelled towards a target carried on an inner end of the vacuum chamber. This target may be any suitable material, such as the skin of a spacecraft, and from these tests it can be determined if meteoroids will damage or penetrate such in space flight. Of course, other tests could be performed on similar objects. The compressor could also be used for providing a dense high temperature plasma that may possibly have many applications and use.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

What is claimed is:

1. An apparatus for producing high temperature compressed plasma comprising:

a. an elongated cylindrical first electrode;

b. a central rod electrode disposed coaxially of said first electrode out of contact therewith;

c. an electrically conductive element extending between said central rod electrode and an inner end of said first electrode;

d. means for applying a high voltage to said first electrode and said central rod electrode for causing said electrically conductive element to ionize producing a plasma which is accelerated out of the outer end of said first electrode;

e. an insulating connecting means carried on an outer end of said first electrode;

f. an elongated electrically conductive helical coil having a large diameter end and a small diameter end;

g. said large diameter end of said helical coil being connected to said connecting means and said small diameter end being spaced longitudinally therefrom;

h. means for electrically connecting said small diameter end of said helical coil to said first electrode;

i. said helical coil being in axial alignment with said elongated cylindrical first electrode so that a current path is formed between an outer end of said central rod electrode and said helical coil as said plasma is accelerated out the outer end of said first electrode producing current flow through said helical coil which in turn produces a time varying magnetic field that compresses said plasma adjacent said small diameter end of said coil;

j. whereby a source of high temperature compressed plasma is produced adjacent said small diameter end of said helical coil.

2. The apparatus as set forth in claim **1**, wherein said electrically conductive element is a thin circular aluminum member which is ionized by said high voltage.

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